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Enterprise Systems for Faculty Information in Universities: Implementation Challenges

Abstract

It should only be natural that universities have centralized database systems that record the most important academic contributions that they make as centers of learning. This information is typically related to their research, service, and teaching. Although the university has enterprise systems for finance, students, human resources, grants, and endowments, they do not have enterprise systems for faculty productivity data. This data is typically stored in unstructured form in faculty curriculum vitae, annual reports, promotion and tenure dossiers and faculty web profiles. The information is unstructured and decentralized making it extremely difficult to provide aggregated insights into faculty contributions. It is often left to external agencies like ranking and academic publishers to collect this data and sell it back to universities so that they may get a better grasp of their performance. Numerous reasons have been given as to why this is the case. These reasons include faculty data are diverse and vary from department to department, it is cumbersome to collect the data, there are no resources to do this, intellectual property challenges, faculty time, lack of systems and so on. Lately there has been a proliferation of such systems for faculty data to be stored in enterprise systems. Most adoption has been done at the college level primarily driven by accreditation requirements. In this paper, we make a case for enterprise wide adoption of such systems and demonstrate the importance of doing so. We provide an overview of the technologies available and how they are being used. We describe one such system, Lyterati, and demonstrate its adoption at the enterprise level by some universities. We conclude by reviewing the ongoing challenges that universities face in adopting and implementing enterprise level faculty systems and how to overcome them.

Keywords: Enterprise systems, Business intelligence, Faculty data, Higher Education

Enterprise Systems for Faculty Information in Universities:

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1.0 Introduction

Universities are active knowledge centers positioned to spur innovation in our economy (12). The U.S. is home to many of the world's reputable colleges. To achieve this distinction, universities recruit the best students from around the globe, conduct innovative research, and grow and expand to serve more students. The number of 4-year colleges has proliferated to over 3,000 (21). The driving factor in the growth of universities and the expansion of knowledge is the importance of academic contributions to society. The research, teaching, and service that faculty provide are the building blocks of the academic contributions. This is what spurs economic growth and results in the increased demand for education. Better management and governance of university academic resources is linked closely to university performance (2, 20).

Although the contributions of the faculty are critical to academic performance, universities have little grasp of the data that faculty activities produce (4). The data are highly unstructured and exist primarily in faculty curriculum vitae (CV), which is a self-organized record of their activities. Universities collect this information at the departmental level through CVs, annual reports, and promotion and tenure dossiers. Structured information, such as journal publications and books are easier to collect from external sources making them the single most important and visible contribution that faculty provide. If one looks at a university's strategic plan the goals stated are much broader and range from ethical leadership, global exposure of faculty and students, entrepreneurship and other objectives that are often not reflected through publications alone. Not that these objectives cannot be measured, but the lack of information collected related to non-publication oriented activities makes it difficult to measure. Even publications are not kept track of by universities centrally but are left to individual faculty to account for and keep track of.

Figure 1. Faculty Contributions

Faculty information systems are envisaged to have data related to faculty publications, teaching, research, demographic, education, grants, awards, professional experience, consulting, media and other presentations, patents, creative works, and entrepreneurship among others (Figure 1). The CV portfolio expands as faculty gain experience in one or more universities and is a track of their contributions to higher education. It has become a stylized document for personal and departmental use. The information stored in here, if used effectively by universities, can promote dissemination of faculty contributions by making it easier to transfer knowledge much needed in society and for economic development (12). Some knowledge transfer is accomplished through curricula and students. However, there is a wide gap in direct knowledge transfer from universities when it comes to industry, government, and other organizations. An improved mechanism of this knowledge transfer could happen through information exchanges. To get there, universities need to harness this information through a transformation from unstructured to structured knowledge that are embedded in faculty activities.

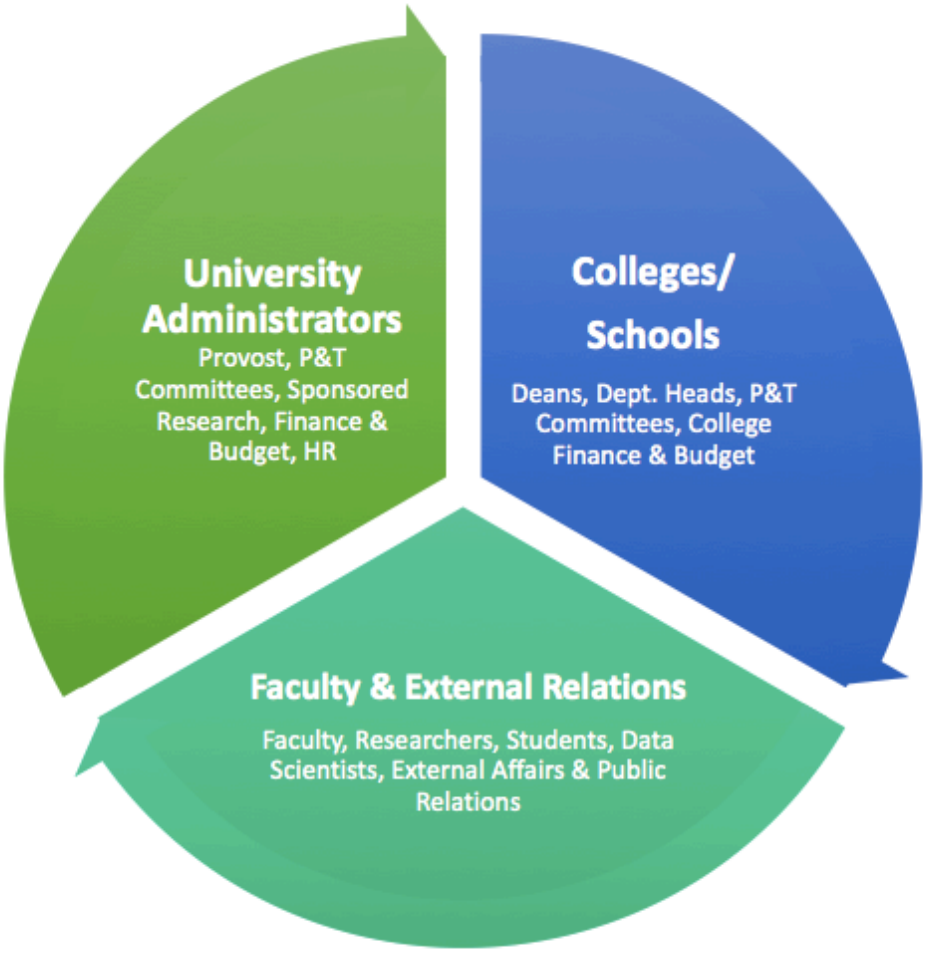
Traditionally, when universities want to aggregate all their faculty information for reporting purposes, administrators contact each faculty member via email, phone call, or in-person and ask for faculty activity and accomplishment records. This occurs every time a report is required, and reporting could be requested several times a year. Academic administrators typically do not have the budgetary resources to digitize faculty information and cannot make the decision to do so even if they wish to.

Information technology resources are available primarily to the chief information officer (CIO) at the university level. Other administrative information needs like finance, human resources, student registration and billing are activities performed and tracked in a university enterprise system by the CIO. These activities usually take budgetary precedence over faculty activity reporting.

Requests for faculty information come from various units and serve very important academic goals of the university (Figure 2). The updated information is used to assemble faculty annual reports, promotion and tenure documents, activity and research reports, updated web profiles, and accreditation compliance reports. The inability to collect faculty information can lead to loss of opportunities related to attracting better students and faculty, obtaining grants and contracts awards, raising endowment funds for the university and the inability to provide faculty productivity data to stakeholders and ranking agencies.

When faculty are asked to provide information, they update their CVs in response to the request. CVs act as central repository for faculty contributions. The move from updating a CV to updating a database can be a challenging behavior modification. Data entry is not a forte of faculty, although maintaining a CV is a similar activity. The purpose of a CV in other professional disciplines is to use it as a marketing tool to showcase skills, creativity, and accolades; whereas, the purpose of faculty CVs is to collect information for annual reporting and promotion and tenure decisions. It is conceivable that the faculty CV may become obsolete when all faculty achievements are recorded in a database. The faculty CV then becomes a report that can be generated by a system.

Figure 2: Primary Users of Faculty Information



In this paper we demonstrate the importance and need for tracking faculty intellectual contributions in a structured centralized manner. We discuss the state of software development and implementation in this regard. The reasons for successes and failures are discussed. We show how one of these centralized systems has been deployed successfully at universities at the enterprise level and the challenges faced. We conclude by making recommendations on how enterprise level faculty systems can be deployed and the ongoing challenges that universities will face in making this transition.

2.0 Review of Faculty Information Systems

The established ERP providers such as Ellucian, Oracle, SAP, Workday, and IBM have not created software and systems to service the faculty information systems market, but many smaller companies have addressed university needs in this area. Some companies offer solutions with the full panoply of options supporting collection of faculty contributions, faculty web profiles, workflow based faculty annual reporting, workflow based promotion and tenure decision making; and faculty-related administrative processes like sabbatical, leave management, compensation management, and faculty recruitment. This is still an untapped market with no true market leader; companies are entering into the marketplace by offering selected services, and are expanding their list of services to include more options.

Broadly classified, based on functionality, there are three types of products in the market:

1. Faculty Profile Management Systems. These are systems that support the development and support of faculty profiles on the web. These systems are distinguishable from others as their primary focus is to get faculty data from external sources complemented by faculty addition of data. Examples of this type of software include the following:

- **Curvita** (8) is a software created by SciMed Solutions. The software solution provides profile management for faculty members.
- **Pure** (10**)** created by Elsevier, is a centralized research database system, where researchers can create profiles, establish author networks, and discover fellow experts.
- **Thomson Reuters** (14) created **InCites** and **Converis** that supports universities, research institutions, and funding agencies with a web-based research evaluation platform, allowing faculty to insert publications and activities and create web profiles.
- **Elements** (26) by Symplectic is a faculty system that is used to collect and showcase scholarly activities, generate standardized CVs, and produce reports.

- **UNIweb** (6) is a software by Proximify that allows faculty members to upload activities, create web profiles, and aggregate data for reporting.

2. Benchmarking Systems: These systems are geared towards collecting data from publicly and externally available sources. They provide universities dashboards that allow them to do comparative analyses with other universities and researchers. Their primary use is for benchmarking and for comparative performance analysis.

- **Academic Analytics** (1) is a software used for benchmarking and decision making using publicly and externally available data.
- **InCites** (14) from Thomson Reuters can also do benchmarking and compare to peers.

3. Faculty Enterprise Systems: These are administrative faculty systems geared towards supporting all faculty related academic and administrative functions that are typically not supported by commonly available HR systems. These are meant to be used centrally by the university, like other enterprise systems. Some examples of these systems follow.

- **Lyterati** (19) by Entigence is a full-service faculty ERP system, which supports faculty contribution management, annual reporting, promotion and tenure processes, dynamically updated web profiles, ad-hoc reporting, faculty leave requests, compensation management, sabbaticals, and faculty recruitment.
- **Activity Insight** (9) by Digital Measures is widely used at the departmental and college level at universities. This cloud based software provides features such as activity reporting for annual reports, promotion and tenure reporting, web profiles, accreditation reporting, CV generation, integration with other systems, and other administrative reporting requirements.
- **Mentis** (15) by Inknowledge, Inc. provides workflow capabilities to streamline tenure and promotion, grants management, annual reviews, and performance evaluations.

- **Faculty180** (11) by Data180 (and now owned by Interfolio) is faculty software that allows annual reporting, promotion and tenure reporting, CV generation, web profiles, accreditation reporting and contribution management.
- **FAR Suite** (22) by Resolutions Applications is a software that faculty can use to update profiles, showcase research, scholarship, teaching and service activities, and generate reports for promotion and tenure decisions.
- **Sedona** (24) by Sedona Systems is a full-service enterprise system that allows for accreditation reporting, ad hoc queries, scorecards, and web services.

Table 1 provides a comparative analysis of these faculty information systems.

Although a wide variety of systems exist today, implementing faculty systems at the university level has been a major challenge. Some of the challenges are technological, however, the more severe challenges are cultural and a lack of commitment at the university level to implement such systems. It is not clear from implementations (or the lack thereof) whether universities view these systems as performance management systems, research information systems, human resources systems, or simply that the university does not feel a need for any centralized system as these are largely departmental or college level responsibilities. Universities are still struggling to get answers to these questions; however, the reality is that they continue to be devoid of systemic reporting capabilities for faculty contributions. In the following sections we describe the development of one such system and summarize the challenges of implementing such systems.

Table 1. Comparative Analysis of Faculty Information Systems Software

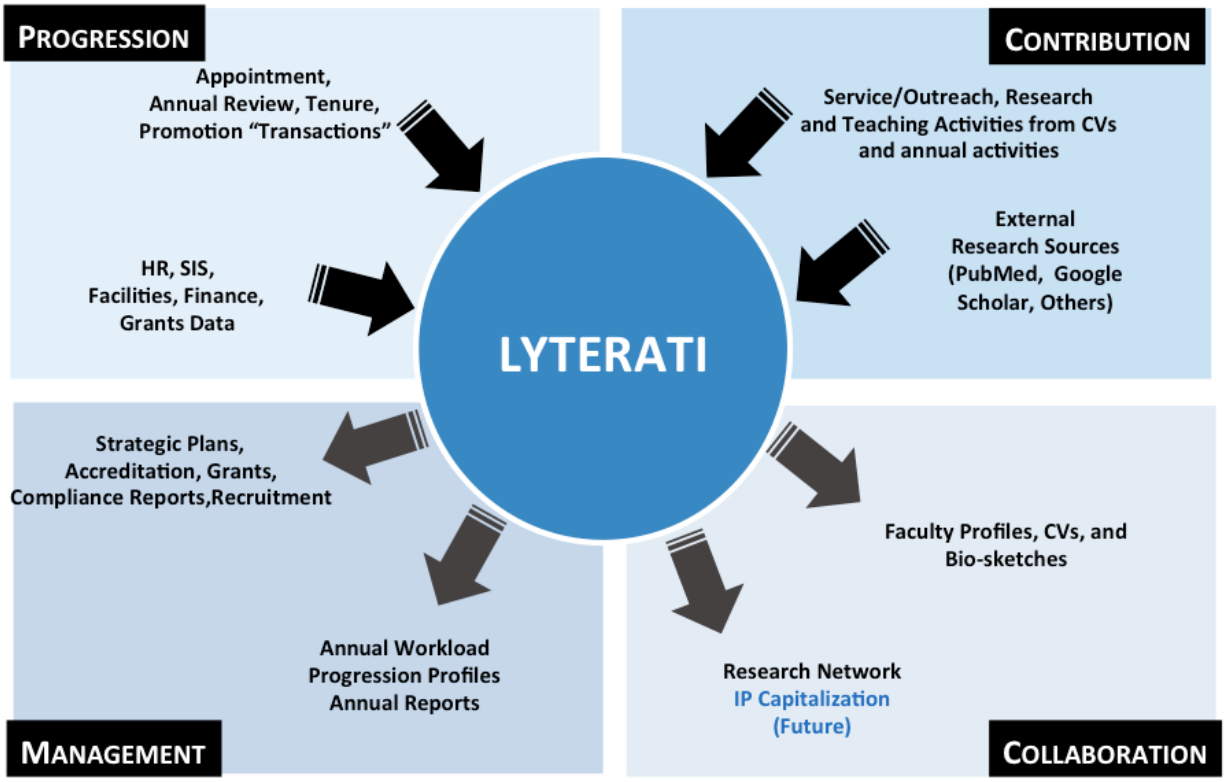
Software	Edit/Enter CV	Create Faculty Annual Report	Manage Promotion & Tenure	Deliver Dynamic Web Profile	Admin. Processes Recruit, Sabbaticaal
Curvita	✔	✔	✔	✔	✘
Pure	✔	✔	✘	✘	✘
InCites/ Converis	✔	✔	✘	✘	✘
Elements	✔	✔	✔	✔	✘
UNIweb	✔	✔	✘	✘	✘
Acad. Analytics	✔	✔	✘	✘	✘
Activity Insight	✔	✔	✔	✔	✔
Lyterati	✔	✔	✔	✔	✔
Faculty Productivity	✔	✔	✔	✔	✘
Faculty180	✔	✔	✔	✔	✔
FAR Suite	✔	✔	✔	✔	✘
Sedona	✔	✔	✔	✔	✘

3.0 Building and Implementing an Enterprise Faculty Information System: The Case of Lyterati

Lyterati is an enterprise solution created to satisfy the need for comprehensive information regarding faculty. The development of Lyterati was lead by one of the authors of this paper. It is a cloud-based SaaS (Software as a Service) application where administrators can manage many aspects of their academic activity including faculty recruiting, annual reporting, leave and sabbatical requests, promotion and tenure, grant applications, web profiles, and other functions. The system automates and streamlines workflow processes and houses all faculty data completely owned by the university. Data analytics are also available to help transform data into useful information to assist with academic decision-making.

Lyterati has only been implemented university wide at the enterprise level as opposed to college or department level implementations. Lyterati supports all levels of faculty administration processes – faculty, department heads, deans, and provosts. Universities have a variety of stakeholders who can use Lyterati, and these users require different functions from the system (Figure 2). Users have different roles and, therefore, have differing objectives, expectations, and priorities. When building Lyterati, four components are addressed prior to implementation: 1) Impact of the system on individuals (faculty) 2) Organizational Impact (administration) 3) Information quality, and 4) System quality (16). Impact on faculty can be analyzed by evaluating productivity, decision effectiveness, improvement in individual work quality, and better understanding of faculty activities and their interrelations. Organizational impact can be evaluated through improvement in user service, better communication between departments, overall productivity, and cost reductions. For information quality, content accuracy, content relevance, and availability of information are the criteria for evaluation. System quality can be evaluated through usefulness, error-aversion, ease of use, and integration with other systems (16).

Figure 2: Functional Components of Lyterati



As shown in Fig 2 Lyterati has four functional modules:

• **Contribution Management:** This module manages research, teaching and outreach/service activities of the faculty. The taxonomy for recording contributions is exhaustive and is suited for all disciplines – Medicine, Law, Business, Engineering, Arts, Sciences, and Social Sciences. Faculty can add, edit, delete contributions and can import contributions from other sources. Administrators can import some contribution data from other systems. The contributions are broadly classified into research, outreach/service, and teaching.

Within research there are 9 sub categories, outreach/service has 8 sub categories, and teaching has 5. Each of these sub categories has an average of 10 sub-types resulting in over 200 different ways of classifying faculty contributions. Not all need to be used.

The sub-types are configurable which provides broad flexibility to the University.

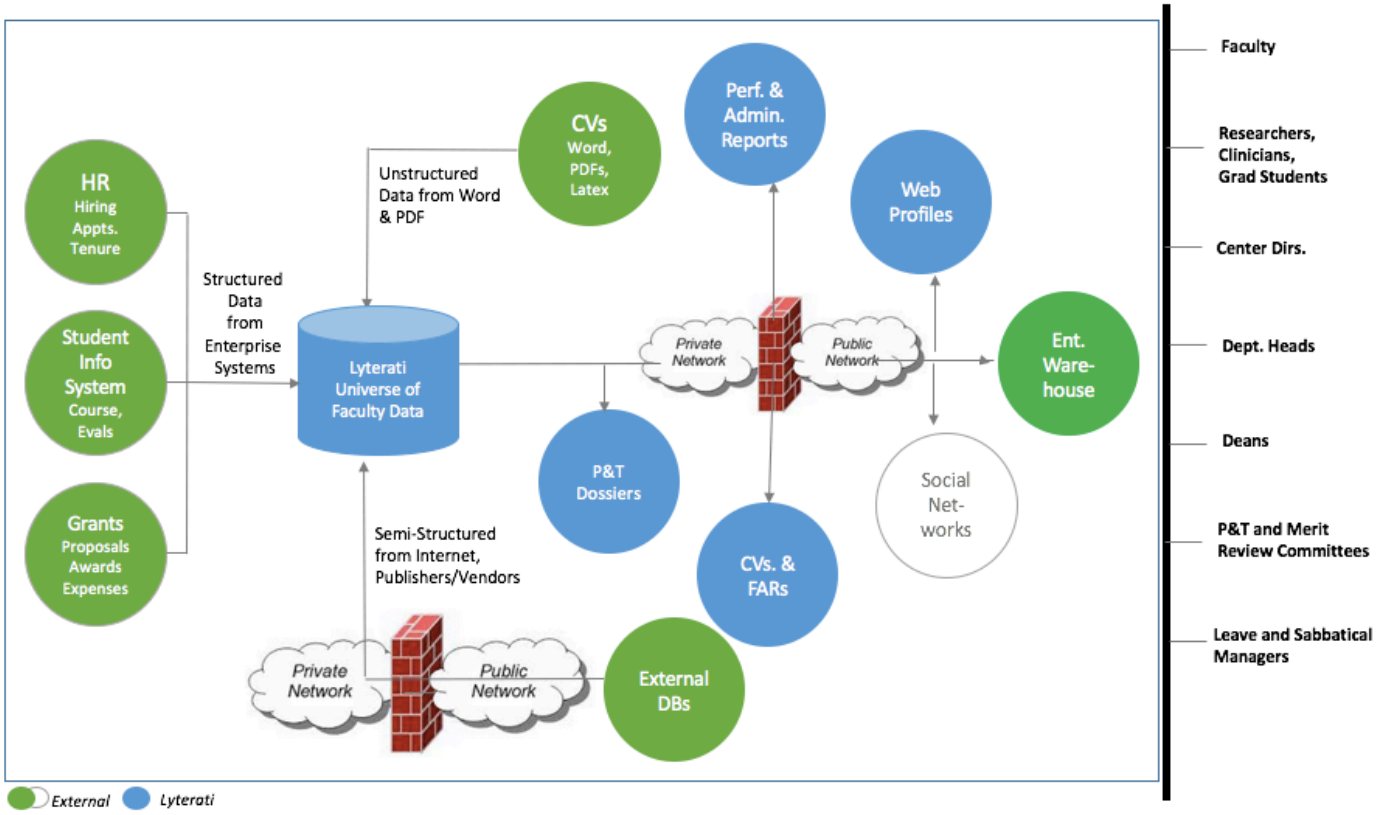
• **Progression:** Faculty members go through an annual evaluation process and a periodic promotion and tenure process. Lyterati manages all the information and process requirements for these progression activities. It offers a dashboard-driven promotion & tenure module where provosts, deans, and department heads each control information and documents that are configured for their comments and evaluations. The progression module supports not only promotion and tenure processes but other evaluation stages such as 1st reappointment and 2nd reappointment and post-tenure reviews. Committees for these processes are configurable and are integrated with the workflow. The progression module has the ability to setup and manage multiple committees and members at different levels in the university from departments to board of trustees with vote tracking. It has support for external evaluators to access the system directly to record/upload external evaluation materials into Lyterati. It provides a secure environment built on a foundation of supervisory chains, which restrict access to only those individuals who are authorized to manage a particular candidate's P&T dossier.

• **Administration:** Management of academic, administrative, joint, and honorific appointments, background information on faculty, tracking of home college/departments, education, training, and certification history are all managed through the administration module. Specific HR processes related to faculty, e.g. leave, sabbatical, recruitment are components of this module. Supporting these modules is an array of workflow-based rules that use "supervisory chains" of who reports to whom to route transactions such as annual reports, promotion and tenure to the right people at the right time. Security is based on two concepts: authentication and authorization. Authentication – who can get into Lyterati – is accomplished by integrating Lyterati with the university's credentialing system (using login and password). A configurable matrix governs authorization, and determines who can see/do what inside Lyterati. Designees of users can be authorized by administrators to act as proxies. Role based privileges and access can be configured in the system.

• **Reporting:** Lyterati is integrated with a Business Intelligence tool for comprehensive reporting for all data included in the system. Ad-hoc reporting is a key feature of Lyterati and can cater to almost any reporting request. Lyterati can produce configurable CVs and bio sketches to support different bio-profile requirements. For expertise search users can search through any open areas of the system through elastic search.

Universities do not yet have a clear vision as to why a faculty information system should be built. Some build the system as a research information system; some build it as a faculty expertise system, some focus on annual reporting for faculty performance management, while others view it as a dossier management system for promotion and tenure. In Figure 3 a comprehensive framework for using Lyterati at a university is shown. The intent of this paper is to integrate these needs to an overarching enterprise system that meets all these needs. In designing and developing such a system it becomes clear that at the core of all these systems is a faculty contribution system that can feed data into all these functional areas. The implementation challenges related to designing and building such a system make the adoption process slow and complicated, leading to frustration among faculty and administrators. While developing Lyterati these concerns and challenges were kept in mind.

Figure 3: Framework of Lyterati Users at Universities



3.1 The Technology Architecture

The technology architecture for Lyterati is shown in Figure 4. Lyterati hosts the application on the cloud. This allows all data to be stored in a safe, secure platform in cloud servers. Open-source technologies are used to create the application using the following: 1) MySQL is used to create databases, 2) Django and Python are used to build and deploy the application, 3) Pentaho Data Integration is used to aggregate all data through the use of Extraction, Transformation, and Loading, and 4) Pentaho BI is used for business analytics / intelligence.

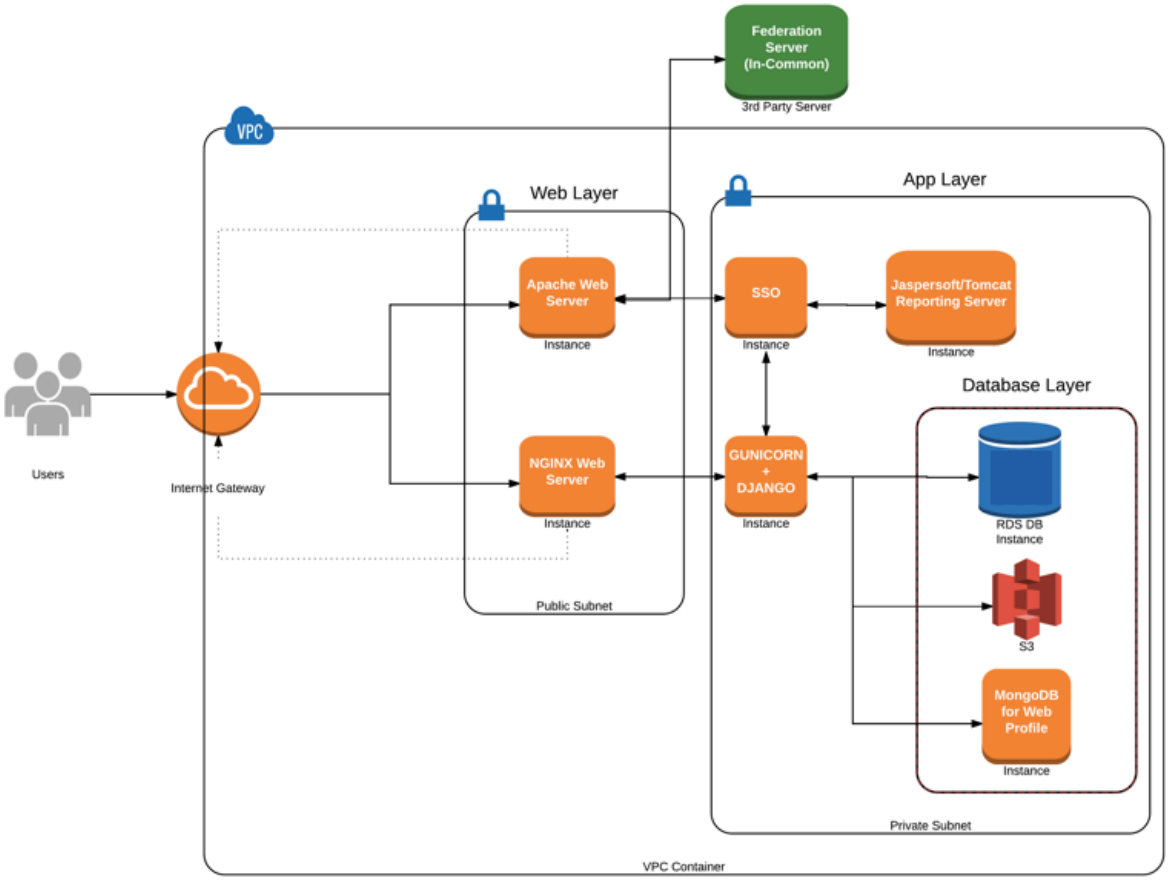
All these components coalesce to create a working solution where each tool complements the other. For example, AWS EC2 provides the server infrastructure, application support for the LAMP (Linux, Apache, MySql, Python) stack, hard drive space, redundant backup services, and cloud security and encryption. Python is the programming language and can be mapped to the MySQL databases through the use of the Object-Relational Mapper. Classes in Python can be mapped to relations in

MySQL. Encryption and cloud security are provided on multiple levels starting with application security and client encryption, later extending to AWS encryption, which only allows encrypted data onto the cloud.

Single sign on (SSO) authentication is required to ensure strict security controls while transferring data through the internet. Once the web server receives the data, more authentication layers are required for data transfer to Lyterati's multi-tenant SaaS application. Data warehouses extract any applicable or necessary data from the database using Extraction, Transformation, and Loading (ETL) processes. The ETL process entails extracting data from databases, transforming the data thru cleaning or aggregating, and then loading these transformed data into a data warehouse. Lyterati's data warehouse then pushes data to a university's data warehouse, if needed, where Lyterati users can create business intelligence reports and dashboards.

Lyterati is powered through open-source technologies. Lyterati can be implemented throughout a university in a matter of months and has been successfully accomplished in several universities. With traditional homegrown systems, to build a product of Lyterati's reach and magnitude would take years and require multiple staff to handle the many specialty areas required. With cloud based secure solutions and a pay-as-you-go business model, cloud based enterprise systems are becoming the standard solution to expedite adoption. It should be noted that universities use a phased approach to implement all the modules. The centralized annual reporting module seems to be the preferred starting point for implementation. It is conceivable that any of the other modules could be used as the starting point for implementation. This continues to evolve and is still unclear as to which module universities will choose to deploy faculty information systems.

Figure 4: Lyterati Architecture



4.0 Implementation Challenges of Enterprise Faculty Information Systems

Central digital repositories of faculty data are a solution to the manual and decentralized process currently being used for information gathering and reporting). This could reduce the redundancy of data entry and also grant new capabilities to universities, as they convert faculty productivity data to meet strategic goals laid out in strategic plans. The use of central faculty data repositories governed by central IT, however, is not common in campuses nationwide. This can be attributed to a number of factors ranging from new enterprise systems integration challenges and adoption by information technology (IT) departments to reluctance to use by faculty members and/or administrative buy-in (7, 17).

Enterprise systems adoption requires a top-down focus (23, 25), where the chief academic officer of a university, typically the Provost, must make the decision that it is important for the university to have faculty data in electronic data systems and not text documents A top down initiative is likely to succeed at a university. Resistance from faculty comes in many forms. The provost has a responsibility to convey to faculty that it is critical for research, service, and teaching contributions to be recorded in a systematic manner so that the university's strategic goals and faculty contributions are aligned. The transition to recording this information in a database that is amenable to reporting and reuse is needed for more effective use of faculty intellectual contributions.

Currently the course of action being undertaken for collecting faculty information within universities uses a bottom-up approach. Colleges and departments based on their specific needs for faculty data implement their own systems from vendors. These systems are stand-alone systems generally not integrated with university enterprise systems (7). Traditionally, university enterprise systems from such firms as IBM, Oracle, Ellucian and others focus on needs such as HR, Student Information, and Finance. Since the market for faculty information systems is relatively small, large software vendors have not shown much enthusiasm to venture into this domain.

CIOs do not have a high priority for a faculty information system due to the absence of an IBM or an Oracle heavily marketing their software. This has allowed smaller IT

business solutions companies such as Data 180, Digital Measures, and Lyterati among others to tap this market and satisfy this need. The adoption of these systems has been slow. CIOs are cautious and do not want to upset the status quo until larger corporations with the ability to target upper level university administrators enter this market and top ranked universities embrace this need.

To circumvent this problem, smaller Faculty Information Systems (FIS) companies are employing marketing techniques that target departmental and college levels of universities. A variety of colleges such as business, liberal arts, or medicine may request the services for a FIS. Decentralized users determine the project requirements and scope and customize solutions tailored to their specific needs. For example, the needs of information collection may vary from the College of Business to the College of Medicine, as these colleges require faculty to do research in different domains or perform different activities, e.g. clinical work for medical school faculty. Standardization of the taxonomy required to store data across the enterprise is a major implementation challenge for FIS. A university can have several colleges, so it becomes extremely difficult for smaller firms to promote usage and adoption to several administrative decision makers in each independent college for university wide adoption.

Another deterrent to campus wide adoption can be attributed to the absence of an acceptable platform that can obtain all the disparate faculty data held in MS word, pdf, or other formats and compile them into an enterprise system. This would likely require manual data entry of all historical faculty information into the enterprise system. The onus of entering historical data into the system meets with resistance from faculty and creates implementation challenges.

When implementing any system university wide, there will be technological as well as human challenges. The technology may not be compatible with existing university systems and can create change management issues. The legacy system tradeoff consideration causes universities to continue with old, familiar practices, leading to delayed adoption of newer technologies. Switching costs occur when universities implement new enterprise systems. Users must expend more effort to learn new systems, which can increase their uncertainty about how to perform traditional tasks.

Tasks that were customarily performed routinely with ease must be re-learned. Eventually, this can lead to user resistance and can adversely affect the implementation and lead to failure.

User satisfaction after implementing ERP systems can be influenced by a number of factors. One of the primary factors is fit. This implies that the systems must be closely aligned with the workflow that they are currently used to. For example, can faculty members insert all their publications into the system without increased effort**?** Does the system allow for committee reviews of annual reports? If there is divergence in user expectations and actual use, then satisfaction decreases, which leads to unwillingness to use the ERP system (5, 18).

Entering data in unstructured formats such as Word is efficient for data entry, not for data retrieval. If data entry is the only focus that faculty perceive from administrators, there will be resistance in adopting such systems. Even with a clean, easy-to-use interface, enterprise system use can be found lacking in meeting expectations. The system must be sufficiently populated with existing data to be useful for analytical reporting. If manual data entry is required of faculty members to initially load the database, there could be a resultant lack of participation as these efforts become viewed as more cumbersome than helpful. The inherent questions to ask are:

1) Who populates the system with existing data?

2) How many years back should we go to populate the data?

3) Is there data integration technology available to transfer data from one system to another?

4) Is there a data conversion toolkit available to convert data if a different format is required? and

5) Is there reliable meta data available about the source data for data to be mapped?

The challenges in implementing faculty information systems are many. The transition to enterprise level faculty systems has started. To create awareness and to successfully implement such systems, more research is needed. There are many unanswered questions including some that affect policy making at universities. In the following section we present some of these research issues.

5. Future Research

After overcoming adoption and implementation challenges, the myriad of benefits associated with a centralized enterprise system like Lyterati is significant. The immediate tangible benefits and enhancements include streamlining the reporting process for faculty (including non-tenure track faculty and researchers), integrating business intelligence reporting for decision making, and having up-to-date information for web profiles, impromptu requests for information, and accreditation review.

Conducting annual reviews and preparation of promotion and tenure dossiers for evaluations are ongoing processes that universities engage in every year. With an enterprise system, much of the tedious, arduous work of preparing faculty reviews can be accomplished and shared in a more efficient manner than distributing paper dossiers and exchanging emails between administrators, faculty members, review committees, and external evaluators.

Universities that fully embrace and utilize faculty enterprise systems increase faculty and administrative staff effectiveness. As faculty perform new research or receive new accolades, they can update the database immediately. This removes the need to either wait until the information is requested or until a person documents a collection of experiences at year-end. Administrative staff can better use faculty productivity information to help meet the university's strategic goals.

Many stakeholders stand to benefit with the implementation of a faculty enterprise system. These stakeholders and how they benefit include:

- Marketing: They can increase brand awareness and proactively enhance perception amongst prospective students and alumni. Additionally, with the use of a faculty enterprise system, administrators can more easily provide faculty productivity information to ranking publications like US News and World Report, Wall Street Journal, Princeton Review, and Financial Times.
- Research: The research division can determine the best faculty suited to pursue various grant funding opportunities for the university. The system can be the comprehensive expertise database for the university research office. This would facilitate the creation of an exchange to match research with practice.
- Accreditation: The system provides faculty related information to regional and professional accreditation bodies. The university can more readily exhibit faculty credentials and accolades to ensure adherence to qualification standards required to teach university-level courses.
- Dean, Provost, and President's offices: They can develop information backed strategies on how to shape the perception of students, faculty, and university in the minds of all stakeholders and exert more control over the future academic path of the university. They can more effectively align academic goals with strategic goals of the university.

Systems like Lyterati raise questions regarding intellectual property rights. Reluctance to use a centralized enterprise system can be perpetuated by the age old battle of intellectual property ownership issues. In 1980, the Bayh-Dole Act (3) created a uniform patent policy among the many federal agencies funding research. As a result of this law, universities retain ownership to inventions made under federally funded research. Still, there is an arising debate between who owns the intellectual property (IP) faculty create while employed at a university.

With the advent of software technologies from which royalties may subsequently follow, universities want to remain inclusive of such opportunities. They do this by asserting their right to license patents to companies and industry, with royalties given to the inventors and university. For example, the University of Florida created and patented Gatorade from which faculty receive $11 million per year in royalties (13). Universities

set up Technology Transfer Offices to facilitate the knowledge transfer from universities to the market. In fact, U.S education institutions in aggregate receive over $1 billion from IP licensing revenue; eight schools procured half of that money. The remaining schools that received royalties typically only generated enough to cover the costs of running a Technology Transfer Office, if that; some universities were in the red (13).

During the implementation of faculty systems, questions regarding intellectual property need to be resolved. Since universities grant intellectual property rights often to faculty so that they can publish their own research, it is unclear as to what rights the university has on intellectual property that is created using university resources and compensation. There should be no question that the university retains the right to use faculty contributions for academic purposes. This may need to be clearly stated in faculty handbooks and university policies so that there is no confusion regarding intellectual property rights specially related to the data contained in faculty systems.

Future research in the development and implementation of faculty information systems should address several unanswered questions. Faculty resistance is a seemingly insurmountable challenge. Research needs to identify the causes of such resistance beyond change management issues and help overcome them. It is yet unclear what features and functionalities are needed in these systems, as there are little or no precedents to bank upon. This needs to be addressed by academic researchers and not practitioners who are ill equipped to answer this question.

Numerous data integration challenges exist in the development of faculty information systems. Faculty data lay disparately in various pockets of the university – including HR, grants management systems, course registration systems, course evaluation systems, library databases, publisher databases, and other sources internal and external to the university. Integration of this data poses unprecedented challenges for implementers, leading to universities spending inordinate amounts of time and resources attempting to accomplish this task. Some universities have spent over a decade integrating data to establish a comprehensive faculty system. Research also needs to be done to identify success factors of such implementations. It is unclear how one would measure success (or failure) of faculty information systems implementations.

Factors beyond usage should be included in measuring and demonstrating success of implementations.

One of the perplexing challenges in implementing faculty information systems is privacy and security issues. Certain faculty data are sensitive and need protection and some data benefit from sharing. Challenges related to determining what information should be shared and with whom are often encountered and no consensus exists in its determination. At the granular level, this poses to be a very complex task resulting in falling back upon blanket protection of data with no sharing of data, defeating the very purpose of the implementation.

Since the development and implementation of faculty information systems is relatively new, universities expect a high degree of customization at low cost due to budgetary constraints. The need for customization at low cost is not unique to universities but is widely felt in new areas of software development especially in cloud environments. New architectures need to be developed so that customizations are possible with automation to reduce costs. Additionally, one of the primary goals of faculty information systems is to produce data analytics that would allow administrators to assess alignment of the university's strategic goals with academic productivity. Research into data analytics for faculty information is needed to determine what measurements beyond traditional measures of faculty productivity are relevant.

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